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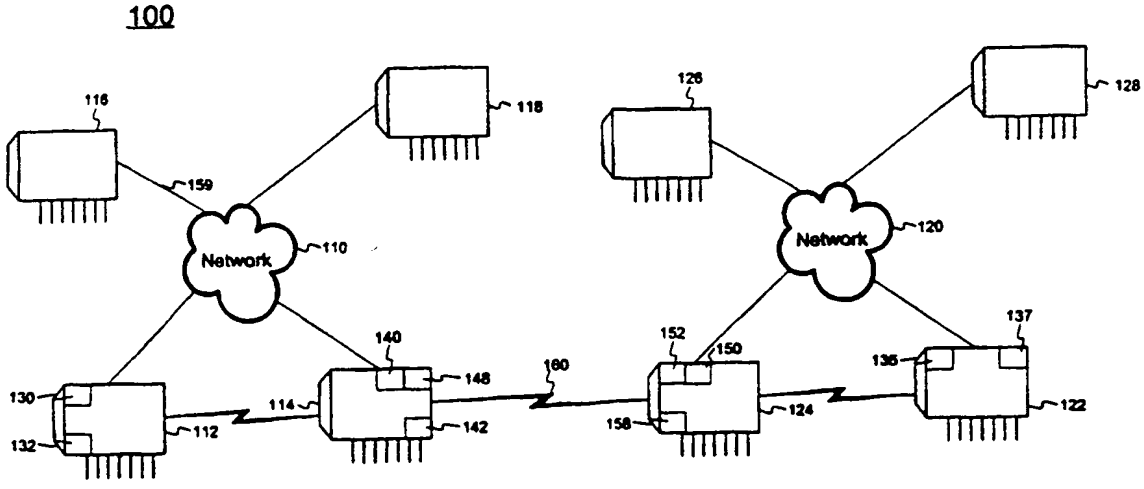
(54) Title: METHOD AND APPARATUS FOR TRANSMITTING ATM OVER DEPLOYABLE LINE-OF-SIGHT CHANNELS



(57) Abstract

A system for transmitting asynchronous transfer mode voice, video, data, and imagery over deployable line–of–sight channels. The system includes an ATM adaptation layer and an ATM cell configuration, which include a flexible multirate encoder and decoder. The ATM cell configuration also entails separate encoding and decoding of header and payload codes, interleaving the header and payload bits, and a methodology for cell synchronization. Using this system, a deployable line–of–sight channel is available for ATM transmissions in a military or tactical environment. Additionally, the system also enables a civilian or commercial ATM channel to operate with a military or tactical ATM channel.

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INTERNATIONAL SEARCH REPORT

Internati Application No
PCT/US 98/01926

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 713 347 A (AT & T CORP) 22 May 1996 see column 6, line 28 - line 35	1-5,25 13-24, 37-54, 133,138, 147
Y	see column 15, line 56 - column 16, line 45; figure 5 see figure 8	9-12, 33-36
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 September 1998	12. 10. 98

Name and mailing address of the ISA	Authorized officer
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8

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International Application No
PCT/US 98/01926

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
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A	FARSEROTU J ET AL: "TCP/IP OVER LOW RATE ATM-SATCOM LINKS" MILCOM 1996. PROCEEDINGS OF THE 15TH. ANNUAL MILITARY COMMUNICATION CONFERENCE, MCLEAN, VA., OCT. 21 - 24, 1996, vol. VOL. 1, no. CONF. 15, 22 October 1996, pages 162-167, XP000697267 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS * section 1 * see figure 2 ---	1-8, 25-32, 36, 133-170
X	AIKAWA S ET AL: "1996 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC), CONVERGING TECHNOLOGIES FOR TOMORROW'S APPLICATIONS DALLAS, JUNE 23 - 27, 1996" 1996 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC), CONVERGING TECHNOLOGIES FOR TOMORROW'S APPLICATIONS DALLAS, JUNE 23 - 27, 1996, vol. 1, 23 June 1996, pages 454-458, XP000625714 INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS	55-68
Y	* sections 3.1, 3.2, 3.3, 3.4 * see figures 2,3 --- -/--	9-12, 33-36

8

INTERNATIONAL SEARCH REPORT

Internatic Application No
PCT/US 98/01926

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
X	TORRES P ET AL: "ADAPTIVE ERROR CONTROL CODING FOR A MOBILE BROADBAND SYSTEM" 1996 IEEE 46TH. VEHICULAR TECHNOLOGY CONFERENCE, MOBILE TECHNOLOGY FOR THE HUMAN RACE ATLANTA, APR. 28 - MAY 1, 1996, vol. 3, no. CONF. 46, 28 April 1996, pages 1751-1755, XP000595814 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS * section III.B *	69,70, 72-74, 81,82, 84-86, 171-173, 181-183
X	EP 0 721 267 A (TOKYO SHIBAURA ELECTRIC CO) 10 July 1996	93,94, 102,191, 194
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INTERNATIONAL SEARCH REPORT

Intern_ ,nal application No.
PCT/US 98/01926

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons.

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

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4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims, it is covered by claims Nos.:

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-8 , 25-32, 36 , 133-170

   Method and apparatus for creating a frame appending a different synchronization character to the cell on alternate frames

2. Claims: 1,4,9-12, 25,33-35, 55-68

   Method and apparatus for encoding the header portion of the cell separately from the payload portion using different error decting/correcting codes

3. Claims: 13-24, 37-54

   Method and apparatus for creating a frame placing into a header portion of the frame the header data from an ATM cell other than the error detecting/correcting codes

4. Claims: 69-92, 171-190

   Method and apparatus for selecting a code to match transmission characteristics of the channel

5. Claims: 93-113, 191-196

   Method and apparatus for computing syndromes of a received word and finding an error locator polynomial from the syndromes

6. Claims: 114-132

   Method and apparatus for transmitting a frame interleaving the payload bits and the header bits

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/01926

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UK SR 27/6,5

(12) **United States Patent**
Fang et al.

(10) **Patent No.: US 6,185,715 B1**
(45) **Date of Patent: Feb. 6, 2001**

(54) **METHOD OF PRODUCT CODE BLOCK ENCODING APPLICABLE TO ENCODING AN ATM CELL**

(75) Inventors: **Juing Fang**, Levallois; **Fabien Buda**, Paris, both of (FR)

(73) Assignee: **Alcatel**, Paris (FR)

( ) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/166,234**

(22) Filed: **Oct. 5, 1998**

(30) **Foreign Application Priority Data**

Oct. 9, 1997 (FR) 97 12594

(51) **Int. Cl.**[7] **H03M 13/00**
(52) **U.S. Cl.** **714/755**; 714 782; 714 793
(58) **Field of Search** 714 753, 755, 714 752, 756, 793, 781, 782, 701, 807, 809, 810

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R. Iwase et al, "A Bit Error and Cell Loss Compensation Method for ATM Transport Systems", Electronics & Communications in Japan, Part I– Communications, vol. 76, No. 3, Mar. 1993, pp. 16–30.

* cited by examiner

Primary Examiner—Christine T. Tu
(74) *Attorney, Agent, or Firm*—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

(57) **ABSTRACT**

The invention relates to a method of encoding a data block comprising first and second zones, the method being of the type consisting in applying product encoding to the block. It comprises first block encoding applied to the first zone, second block encoding applied to the second zone, and third block encoding applied to the data obtained by the first two encodings, but in a direction orthogonal to the first two codes, the three encodings being performed using BCH codes, the first zone being protected by a code that is more powerful than the second zone. The block is constituted by an ATM cell, the first zone corresponding to the header of the ATM cell, and the second zone corresponding to the payload data field of said ATM cell.

7 Claims, 4 Drawing Sheets

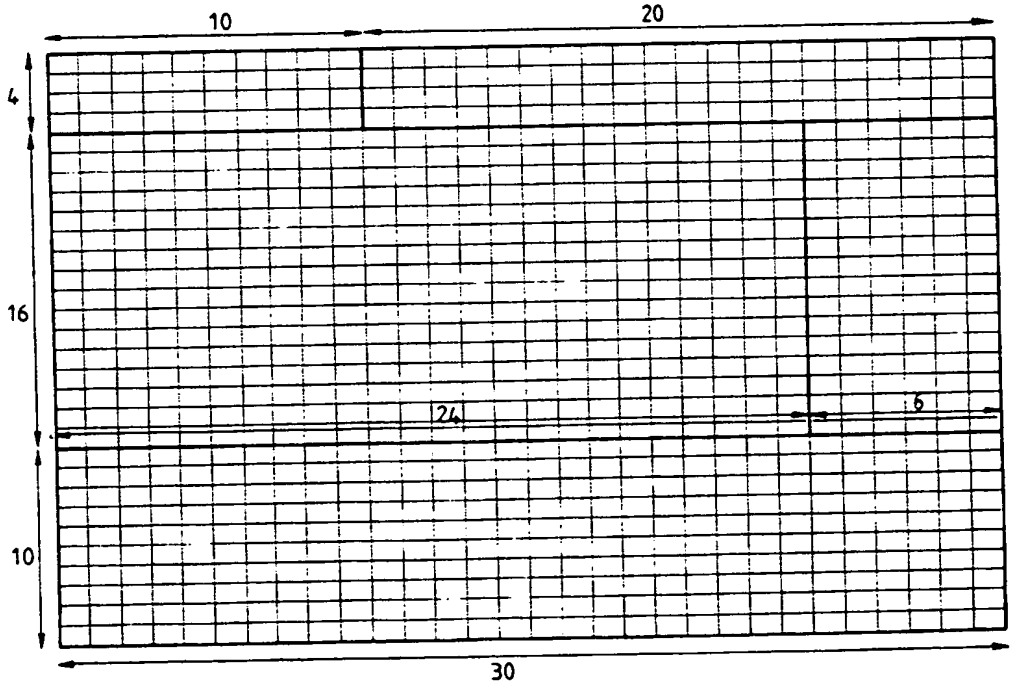


FIG_1

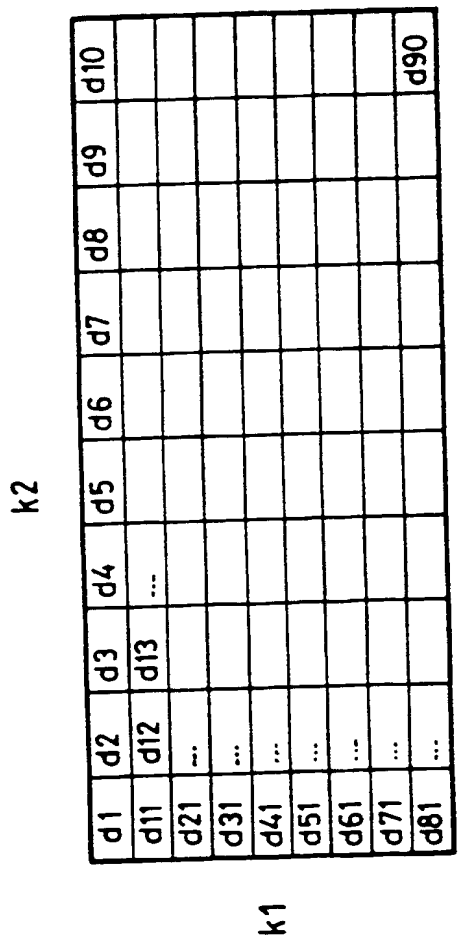

k2
k1
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10
d11 d12 d13 ...
d21 ...
d31 ...
d41 ...
d51 ...
d61 ...
d71 ...
d81 ... d90

FIG_2

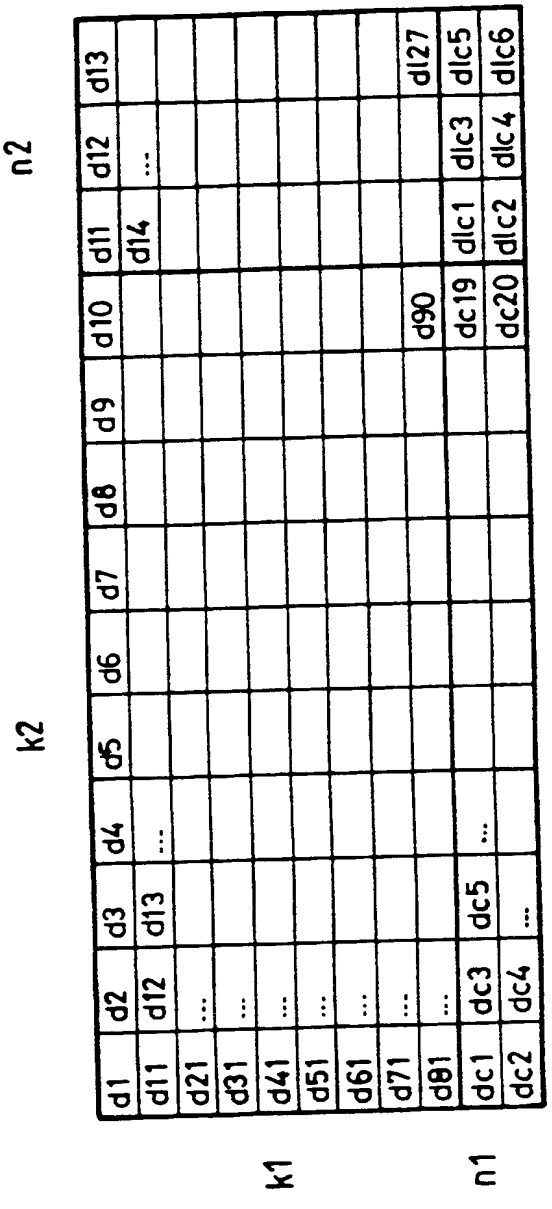
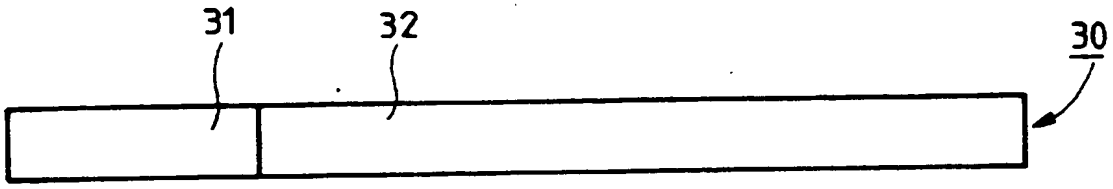

n2
k2
k1
n1
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13
d11 d12 d13 ... d14 ...
d21 ...
d31 ...
d41 ...
d51 ...
d61 ...
d71 ... d90 dl27
d81 ... dc19 dlc1 dlc3 dlc5
dc1 dc3 dc5 ... dc20 dlc2 dlc4 dlc6
dc2 dc4 ...

FIG_3



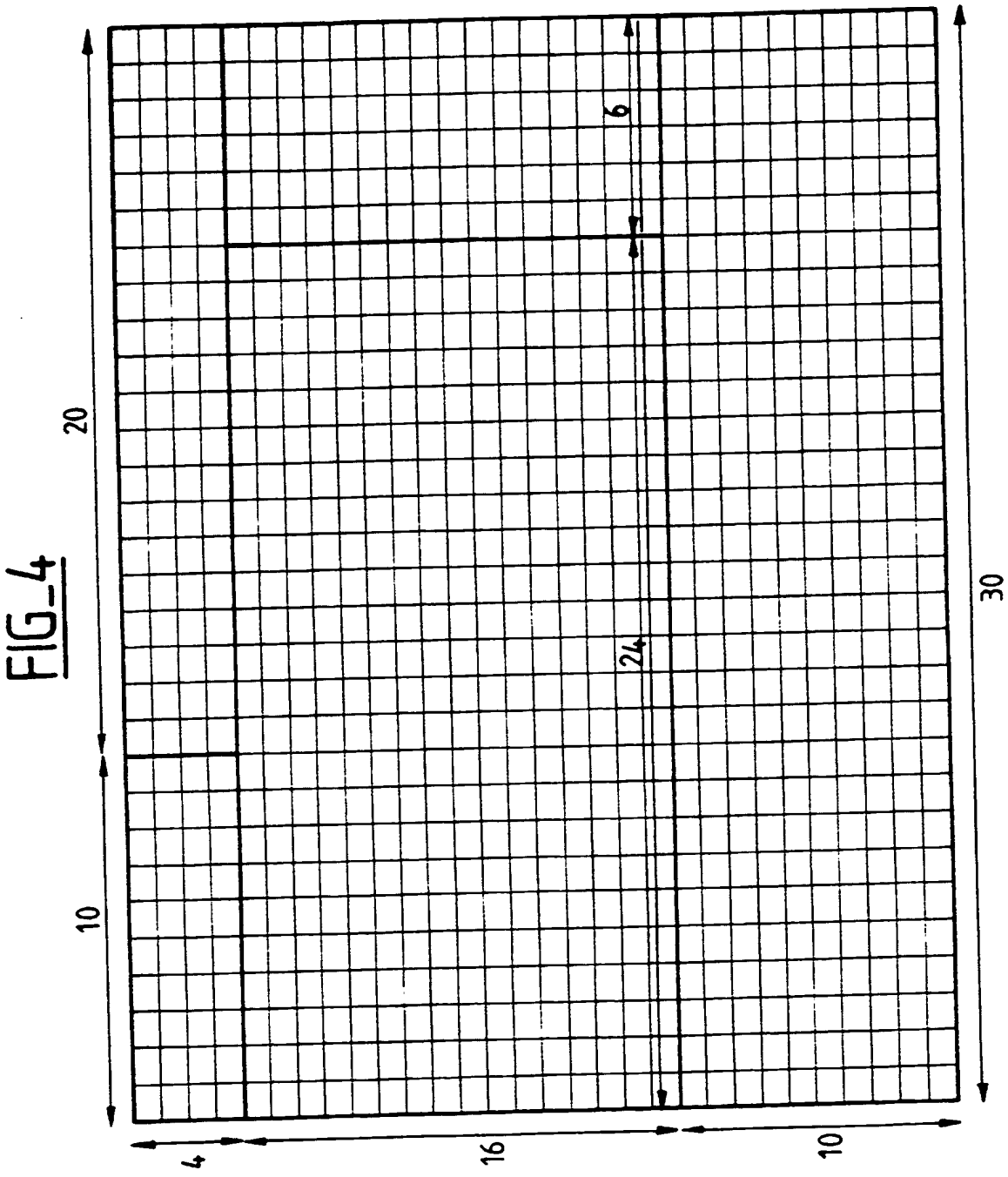
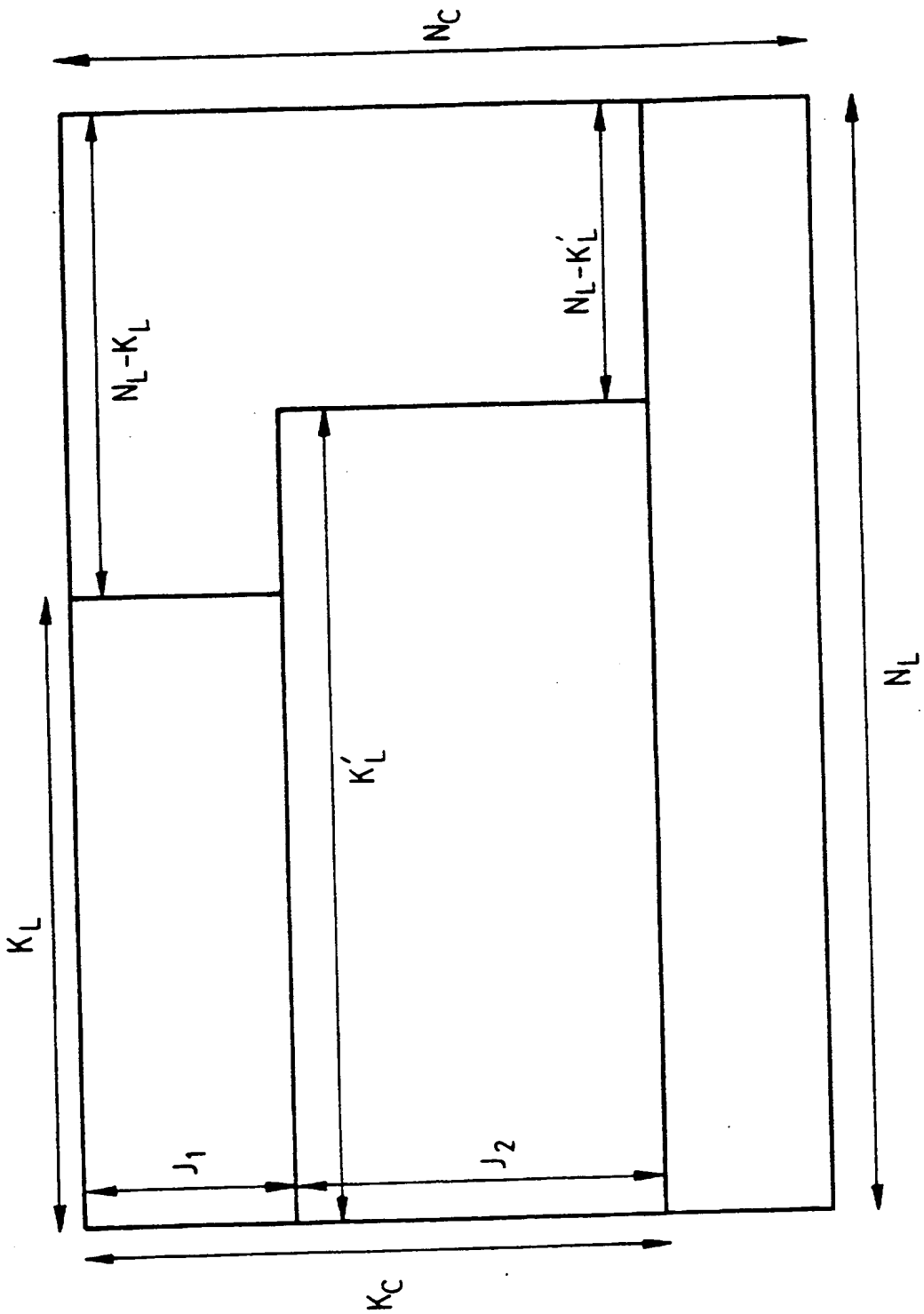


FIG_4

FIG_5



METHOD OF PRODUCT CODE BLOCK ENCODING APPLICABLE TO ENCODING AN ATM CELL

FIELD OF THE INVENTION

The field of the invention is that of encoding data. More precisely, the present invention relates to a method enabling data blocks to be encoded, each block comprising at least a first zone and a second zone, e.g. a header and a zone of payload data. The invention applies particularly to encoding asynchronous transfer mode (ATM) cells.

BACKGROUND OF THE INVENTION

Product code encoding is a known encoding technique that enables data to be encoded for transmission, e.g. by radio. FIGS. **1** and **2** show the principle of product encoding.

In this case a block of 90 bits is to be encoded, wherein the bits are referenced d1 to d90. The bits are organized on a table as shown in FIG. **1**, the table comprising a number k1=9 of rows and a number k2=10 of columns. Product code encoding consists in applying first block encoding (referred to as row encoding) to each of the k1 rows so as to obtain additional bits referenced dli (FIG. **2**) corresponding to encoding each of the k1 rows. By way of example, the bits dl1, dl2, and dl3 correspond to encoding the bits d1 to d10. As a function of the kind of block encoding scheme used, this gives rise to k1×n2 additional bits (in this case n2=3). These bits are placed after the bits from which they are derived, thus obtaining a table that has k1 rows and k2+n2 columns.

After this first encoding operation, a second kind of block encoding (known as column encoding) is applied to the k2+n2 columns, so as to generate n1×(k2+n2) additional bits. In FIG. **2**, 20 additional bits (dei) are thus generated by encoding the k2 columns, and 6 more additional bits (dlei) are obtained by encoding the n2 columns. In this case the value of n1 is equal to 2. By way of example, the encoding of the bits in the first column of the table in FIG. **1** gives rise to bits de1 and de2.

A product code is defined on the basis of the parameters (n1, k1) and (n2, k2) of the row and column codes.

When transmitting ATM cells, it is desirable for the header to be better protected than the payload data field since the header comprises, in particular, the destination address for the cell. If the address is severely degraded on transmission, the packet as transmitted not only fails to arrive at its destination, but it is no longer possible to warn the destination that a packet intended for it has not arrived. Furthermore, when the packet reaches an unknown node, the routing system is disturbed.

A particular object of the present invention is to remedy those drawbacks.

SUMMARY OF THE INVENTION

The present invention provides a method of encoding ATM cells that are to be transmitted, e.g. by radio, said method enabling the cell header to be given better protection than its payload data field.

This object and others that appear below are achieved by a method according to claim **1**.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention appear on reading the following description of a preferred implementation, given by way of non-limiting illustration, and with reference to the accompanying drawings, in which:

FIGS. **1** and **2** show the principle of product encoding;

FIG. **3** shows an ATM cell;

FIG. **4** shows the encoding principle of the invention applied to an ATM cell; and

FIG. **5** shows how the encoding method of the invention can be generalized to ATM cells containing various numbers of bits.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1** and **2** are described above with reference to the state of the art.

FIG. **3** shows an ATM cell referenced **30**. The cell **30** comprises a header **31** containing 40 bits (5 bytes) and a payload data field **32** containing 384 bits (48 bytes). The 5 header bytes comprise six fields including a cyclic redundancy check (CRC) byte, generally referred to as header error control (HEC).

FIG. **4** shows the encoding principle of the invention as applied to an ATM cell.

The invention proposes reinforcing the encoding of the header **31** of the ATM cell compared with the encoding of its payload data by applying different kinds of encoding to these two zones. More precisely, the 40 bits of the header are placed in a zone that is strongly protected by $C(N_f, K_f')$ row encoding while the 384 payload data bits are placed in another zone that is protected less strongly by $C(N_f, K_f')$ row encoding. After the two kinds of row encoding have been applied, $C(N_c, K_c)$ column encoding is applied to all of the columns of the matrix. As explained below, it is preferable for the $C(N_f, K_f)$ encoding to be a sub-code of the $C(N_f, K_f')$ encoding.

By way of example, as shown in FIG. **4**, the 40 header bits are placed in 4 rows of 10 columns each, while the 384 payload data bits are placed in 16 rows of 24 columns each.

Thereafter, the first step of the method, referred to as step a, consists in applying first row block encoding to the header bits, said first block encoding being Bode-Chaudhuri-Hocquenghem (BCH) encoding of the (30, 10) type. Thus, for each 10-bit word, 20 code bits are obtained which are placed after said 10-bit word (in a 4×20 matrix). The second step of the method, referred to as step b, consists in applying second row block encoding, in this case of the (30, 24) type, to the sixteen 24-tuplets of payload bits, thereby obtaining 16×6 code bits following the 24-tuplets. This provides a table of 20 rows and 30 columns.

To perform product encoding, an additional step, referred to as step c, consists in applying third block encoding, in this case a column code, to the data obtained during steps a and b. This third block encoding is of the (20, 30) type in this case and generates 30 10-bit code words.

The final result is thus a table of 30 rows by 30 columns containing not only the source data to be transmitted but also the code bits obtained in steps a, b, and c.

The codes used for constructing the product codes in the present invention are binary BCH codes, and (n, k) binary cyclic codes, their (n+1, k) extents, and their (n, k−1) expurgates, and shortened codes of these (n−s, k−s), (n−s, k−1−s), and (n+1−s, k−s) codes with k, n, and s integers and s<k.

The extended codes are obtained by adding a parity bit to each word of a cyclic code having an odd minimum Hamming distance. In other words, its generator polynomial g(x) does not contain the factor (x+1). An expurgated code is obtained from a cyclic code having g(x) as its generator polynomial, g(x) not containing the factor (x+1). The expurgated code is obtained by the new generator polynomial (x+1).g(x).

Binary expurgated codes and extended codes have all of their code words of odd length. The expurgated code obtained by (x+1)·g(x) is a sub-code of the code generated by g(x). All of the shortened codes are sub-codes of block linear codes, but an extended code is not a sub-code of its main code.

The C(n, k) code is a sub-code of a C(n, k') code where k<k', if all of the words of the C(n, k) code also belong to the C(n, k') code. With a linear block code, this means that the C(n, k) sub-code is a sub-space of the C(n, k') code. For cyclic codes, the main code C(n, k') has its roots in the set of roots of its C(n, k) sub-code. In other words, if the C(n, k') code is generated by its generator polynomial g(x), the C(n, k) code generated by g(x) is its sub-code if g'(x) divides into g(x) in the GF(q) [p_m(x)] domain where GF(q) is the symbolic finite Galois body of the C(n, k) and C(n, k') codes, and p_m(x) is the polynomial which defines the finite body in which the roots of the generator polynomials of these cyclic codes are to be found. If this property is satisfied, then all of the rows of the matrix are words of the C(N_l, K_l) main code.

Using the following notation, as shown in FIG. 5:

- J_1 is the number of rows in the table containing header bits;
- K_l is the number of columns in the table containing header bits;
- J_2 is the number of rows in the table containing payload bits;
- K_l' is the number of columns in the table containing payload bits;
- K_c is equal to J_1+J_2;
- N_l is the number of columns in the table after row encoding has been applied in step a and b; and
- N_c is the number of rows in the table after column encoding has been applied in step c,

then: the first row encoding applied is (N_l, K_l) code, this encoding being applied on the J_1 rows, the second row encoding applied is (N_l, K_l') code, this encoding being applied on the J_2 rows, the column encoding applied is (N_c, K_c) code, this code being applied on the N_l columns.

In this case, the codes used are (31, k) BCH codes, optionally extended (32, k) codes and optionally expurged (31, k−1) codes, and all shortened versions thereof (31−s, k−s), (32−s, k−s), and (31−s, k−s−1) codes, where d is the BCH distance and s is an integer in the range 1 to k−1. The value of k is 6, 11, 16, 21, or 26.

By way of example, (29, 24), and (29, 14) codes are shortened codes of (31, 26) and (31, 16) BCH codes, (29, 8) code is a shortened code of (31, 15) code, and (31, 15) code is an expurgated code of (31, 16) code. Consequently, (29, 14) and (29, 8) codes are sub-codes of (29, 24) code.

The following table shows three different configurations of the codes used as a function of header size.

Configuration	K_l	K_l'	K_c	J_1	J_2	N	K	R	Byte+
1	29	24	8	5	16	899	424	0.47	5
2	29	24	14	4	16	725	440	0.61	2
3	29	24	8	10	16	928	464	0.5	5

The number N corresponds to the total number of bits after encoding, i.e. $n=N_l \times N_c$. K corresponds to the number of bits in the cell to be encoded, i.e. $K=J_1 \times K_l + J_2 \times K_l'$, and R corresponds to the resulting efficiency, i.e. R=K N. The Byte+ column corresponds to the number of bytes added to the header compared with the basic configuration having 5 bytes.

Configuration 1 corresponds to that shown in FIG. 4. Configuration 2 corresponds to that obtained by adding 2 bytes to the header, and configuration 3 to that obtained by adding 5 bytes to the header.

It is desirable to add such bytes when it is desired to transmit a certain amount of additional information together with the ATM cell, e.g. data relating to link monitoring, to signalling, or to additional CRC encoding.

Naturally, the terminology "row code" and "column code" is not restrictive, i.e. two column codes could be applied in succession before applying a row code to the set of encoded data and the same result can be obtained, i.e better protection of the header. This amounts to interchanging rows and columns. The essential point is thus to apply two first encoding operations followed by a third encoding operation in a direction that is orthogonal to the first two.

In an advantageous implementation, provision is made for the rows to be interlaced before applying column encoding (step c). If two column codes are applied before row encoding, then interlacing should be applied to the columns before applying a row code. Such interlacing makes it possible to simplify decoding the column code because decoding the line code of the header provides decisions that are more reliable. Bits that are decided on with a high degree of reliability can be considered as fixed in the words of the column code.

What is claimed is:

1. A method of encoding a data block comprising first and second data zones, said method comprising:

(a) encoding said first data zone using a first block encoding;

(b) encoding said second data zone using a second block encoding; and

(c) encoding the data obtained from steps (a) and (b) using a third block encoding in a direction orthogonal to the first and second encodings, wherein said first block encoding is more powerful than said second block encoding so that said first data zone is more protected than said second data zone.

2. A method according to claim 1, wherein said step (c) further comprises interlacing said data obtained from said steps (a) and (b) prior to encoding the data obtained from said step (a) and (b) using said third block encoding.

3. A method according to claim 1, wherein said first block encoding is a sub-code of said second block encoding.

4. A method according to claim 1, wherein said data block comprises an ATM cell, said first data zone comprises a header of said ATM cell, and said second data zone comprises a payload data field of said ATM cell.

5. A method according to claim 1, wherein said first, second, and third block encodings are performed using Bode-Chaudhuri-Hocquenghem (BCH) codes of length n and dimension k, said BCH codes belonging to any one of the following families: (n, k), (n, k−1), (n+1, k), (n−s, k−s), or (n−s, k−1−s), and (n+1−s, k−s), where k, n, and s are integers with s<k.

6. A method according to claim 1, wherein said first and second encodings each comprise a row code and said third block encoding comprises a column code.

7. A method according to claim 1, wherein said first and second encodings each comprise a column code and said third block encoding comprises a row code.